

DEFINITION OF OCCUPANT BEHAVIOUR PATTERNS WITH RESPECT TO VENTILATION: AN APPROACH TO THE SUMMER THERMAL COMFORT OF APARTMENTS FROM THE REAL ESTATE MARKET OF SANTIAGO DE CHILE

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Occupant behaviour, ventilation patterns and thermal performance of dwellings

It has been demonstrated that there is a strong relationship between occupant behaviour and thermal performance of dwellings. Indeed, some variables related to occupant behaviour constitute some of the main sources of uncertainty in the field of building energy simulation. In that sense, depending on the variability of aspects such as scheduled internal gains or natural ventilation, a wide range of variation in the energy consumption of dwellings may be expected. Consequently, the definition of a set of standard behaviour patterns – based on the quantification of real inhabitants’ behaviour - would significantly improve the validity of the outcomes of the simulations. The aim of these models - based on multivariate analysis methods - corresponds to the definition of behaviour scenarios which can be used as hard data to make calculations of energy performance of dwellings more accurate and reliable.

Principal Component Analysis (PCA)

A PCA was carry out in order to reduce the dimensions of a large set set of variables, which were obtained from a survey applied to 91 randomly selected apartments in a pilot case study during two summer months. The questions applied were selected since they represent different aspects related to the perception of thermal comfort, natural ventilation and strategies that affect the thermal behaviour of apartments.

Table 1.- Considered variables for the PCA

Variables		
Subject	Question	Name
Perception of thermal comfort	Q6	Thermal sensation in the apartment during winter
	Q10	Thermal sensation in the apartment during summer
Ventilation	Q16	Daytime ventilation in winter
	Q20	Daytime ventilation in summer
	Q24	Night ventilation in summer
	Q13	Presence of external solar protection
Strategies and systems	Q27	Use of heating systems in winter

Table 2.- Rotated component matrix of the PCA

Questions	VARIMAX rotated components				Communalities
	C ₁	C ₂	C ₃	C ₄	
Q6	0.02	0.85	-0.02	0.19	0.76
Q10	-0.22	0.15	0.65	0.13	0.52
Q13	0.01	0.00	0.11	0.90	0.82
Q16	0.76	0.20	-0.26	0.24	0.75
Q20	0.86	-0.16	0.14	-0.16	0.81
Q24	0.14	-0.06	0.84	-0.03	0.74
Q27	0.05	-0.71	-0.14	0.44	0.72

Significant variables for each component (coefficient value > 0.60)

Multivariate logistic regression model

With the aim of predicting the level of incidence of the variables that determine the perception of thermal comfort, a multivariate logistic regression model was proposed. The question Q41 (“Do you feel comfortable in your apartment in terms of thermal comfort”) was defined as dependent variable (for the answers “Yes”=1 and “No”=0).

Table 3.- Equation and obtained coefficients from the logistic regression model using the factor scores obtained from the PCA as independent variables

$$P_{(Q41=\frac{1}{C_{i,j=1...4}})} = \frac{1}{1 + e^{-(a + b_1C_1 + b_2C_2 + b_3C_3 + b_4C_4)}}$$

Independent variables	Coefficients		Standard error	z	p-value
-	a	1.97	0.48	4.09	4.38E-05
C ₁	b ₁	0.30	0.30	1.01	0.313
C ₂	b ₂	0.62	0.35	1.77	0.077
C ₃	b ₃	-0.90	0.45	-2.00	0.046
C ₄	b ₄	0.97	0.49	1.99	0.046

Significant variables for: p < 0.01 p < 0.05 p < 0.1

Ventilation profiles by means of a cluster analysis

The hierarchical technique was selected as clustering method in order to classify the obtained observations. Factor scores of the PCA were used as variables for correcting the interdependencies. Four profiles (clusters) were defined in terms of the number of ventilation hours per day. Indoor temperatures in all profiles show the favourable impact of the night cooling strategy to reduce the risk of overheating.

Figure 1.- Number of ventilation hours per day in summer for the four profiles

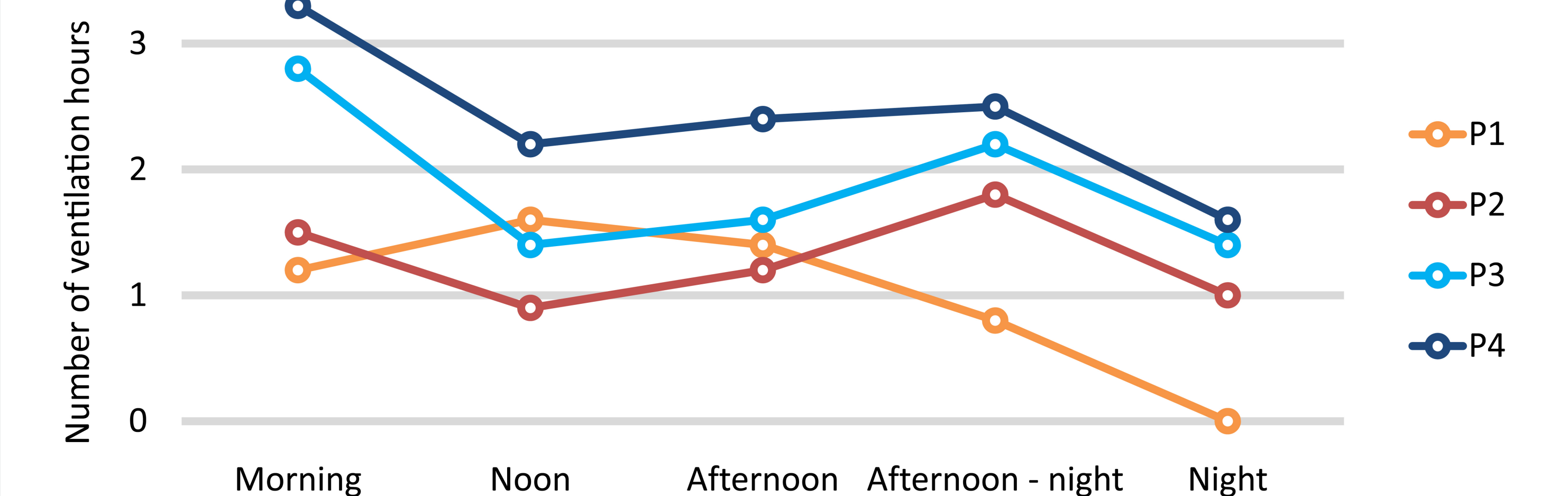
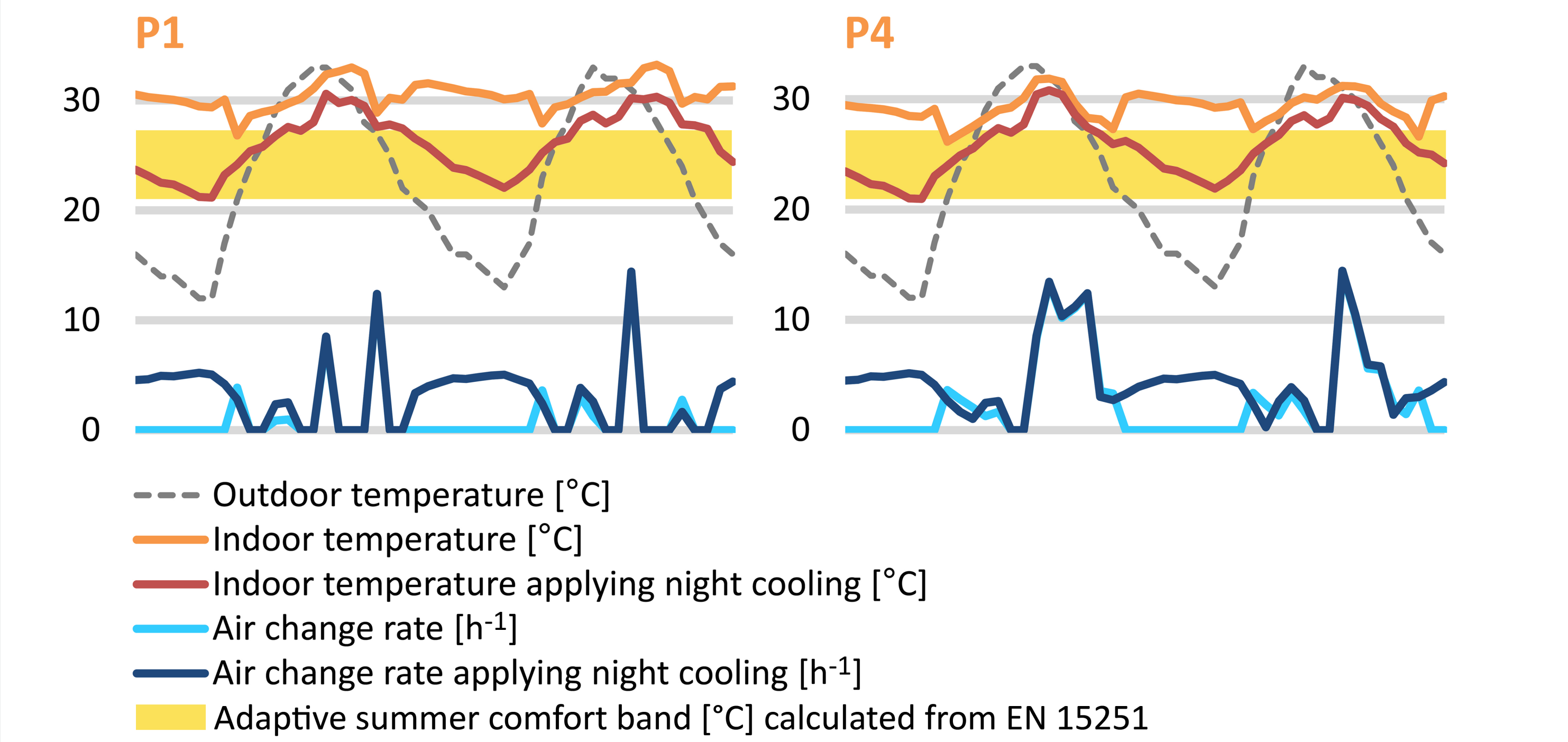


Figure 2.- Curves of temperature [°C] and air change rate [h⁻¹] in two summer days for the main bedroom of a western apartment for P1 and P4 ventilation profiles



Conclusions

The explanatory analysis carried out through the PCA and the logistic regression established the role of ventilation in the thermal sensation of the occupants, associating daytime ventilation mainly with hygienic purposes, while night ventilation appeared directly related to passive cooling. However, if one of the declared objectives of the survey is to provide information for energy building simulations, it is necessary to obtain hard data from the collected information. This was carried out by means of a cluster analysis, establishing ventilation profiles. In consequence, if these scenarios are defined based on a more real approach, the results of the simulation are more representative and reliable and in consequence, uncertainty decreases.